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THE PRESERVATION OF FORESTS.

By F. COLLINGWOOD, M. Am. Soc. C. E.

READ AT THE ANNUAL CONVENTION, JUNE 25TH, 1885.

(Being Appendix No. 1, presented with the Report of the Committee on the Preservation of Timber.)

At the Washington meeting of the Society, the writer had the task assigned him of preparing an appendix to the report on Preservation of Timber, in which should be presented, in brief form, such facts as are obtainable respecting the necessity for exercising economy in the use of forest products, because of the very rapid extinction of forests over considerable areas of our country, and the apparent possibility of what might be called a wood famine.*

Important as the subject is, the information to be had is on many points exceedingly vague and unsatisfactory, and of so general a character as to afford but little basis for exact estimates.

* This matter was prepared in the spring of 1884, before the ninth volume of the U. S. Census was in print. The writer would refer to the latter for additional information on the subjects treated, although it is not such as to change materially the conclusions drawn. The writer holds very positive views as to the value of forests in ameliorating local climatic conditions, but was requested by the chairman to be as brief as possible, and he therefore confines himself rigidly to the economic side of the question.

In connection with the last census, arrangements were made under the intelligent leadership of Prof. C. S. Sargent, of Harvard, for a series of exhaustive reports, which were to cover the whole area of the United States. The final report has not yet been published, and there are many gaps not filled by the bulletins thus far issued. Other sources of information consulted have been the series of valuable papers presented at the Montreal meeting of the American Forestry Congress, maps, cyclopædias and newspaper articles. The statistics are quite full in regard to the available supply and annual cut of white pine, and the several species of Southern pine suitable for timber; less complete as to cedar, spruce, tamarack and hemlock, and very incomplete as to black walnut, ash, oak and other hard and soft woods.

To form any intelligent conclusions it is necessary to consider the subject in detail.

Taking white pine (*pinus strobus*) first, as being at present the most important commercially, we learn that its original area of distribution was, in Canada, from about the 50th degree of north latitude south to the boundary, east to the Gulf of Newfoundland, and west to about Lake Winnipeg. In the United States it occupied portions of Minnesota, Wisconsin, most of Michigan, Pennsylvania, New York and the Eastern States, and extended south in the Allegheny Mountains to Northern Georgia.

The supply and the amount cut in the census year ending May 31st, 1880, are given in the following table:

State.	Amount now Standing.	Cut in Census Year.	Years of Supply at same rate.
	Feet, B. M.	Feet, B. M.	
Minnesota	8 170 000 000	540 997 000	11 years.
Lower Michigan	29 000 000 000	4 085 213 000	7 "
Upper "	6 000 000 000	328 438 000	19 "
Wisconsin	41 000 000 000	2 097 299 000	20 "
Pennsylvania	1 800 000 000	380 000 000	5 "
Maine	475 000 000	138 825 000	3 "
New Hampshire	Original pine all cut.	2d growth. 99 409 000	
Vermont	" " "	2d growth. 6 505 000	
West Virginia	990 000 000	180 112 000	5 "
Totals	87 435 000 000	Omitting 2d growth. 7 750 884 000	11 "

We thus arrive at the astonishing result that in so far as the supply of first growth white pine is concerned, it will be practically exhausted in 11 years. The amounts standing in New York and other States, not mentioned above, are not large enough to change this result, and the cut in the three States first named has greatly increased in the three years succeeding 1880. Even if the supply be double what it is estimated, the necessity is already upon us of conserving to the uttermost these most valuable of our forest trees. "The lumber cut in a single year from the district of Michigan, Wisconsin and Minnesota would load a train of cars nearly 7 000 miles in length, and a single mill in Michigan made 160 000 000 shingles in the same time."

It is well known that from this district, with Canada, our lumber yards now draw the most of their supplies. It is only necessary to visit the southern shore of Lake Superior, Minneapolis and other lumber centers in the vicinity, and see the exceedingly rapid increase of the trade year by year, to become convinced that the estimate given as to time of extinction of white pine in the United States cannot be far wrong.

As to the Canadian supply, Mr. Ward, an intelligent, practical lumberman, places the annual cut of pine lumber at 2 000 000 000 ft., b. m. Of this nine-tenths is exported. The area annually cut over is about 4 700 square miles.

Prof. Hough, of Ontario, says all the timber (meaning, I presume, pine) will be cut in Canada by the end of the present century.

It is stated that lumber is now being cut from points 200 to 300 miles north of the St. Lawrence, or nearly to the extreme northern limits of the pine.

The statistics of the red pine are not given, although in the North it is next in commercial importance to the white pine.

Passing to the various Southern pines, the species of value are principally two: the long-leaved or yellow pine (*pinus palustris*), forming extensive forests in North and South Carolina, Florida and the Gulf States; and the short-leaved or spruce pine (*pinus mitis*), occurring in all the Atlantic States south of New York, in Arkansas and in the Gulf States. Statistics are given as follows:

	Long-leaved Pine Supply.	Cut in the Census Year.	Short-leaved Pine Supply.	Cut in the Census Year	Years will last, both kinds together.
	Ft., B. M.	Ft., B. M.	Ft., B. M.	Ft., B. M.	Years.
Texas	20 508 200 000	66 450 000	26 093 000 000	146 420 000	219
Florida	6 615 000 000	208 054 000	.....	.....	32
Alabama	18 885 000 000	245 396 000	2 307 000 000	.....	87
Mississippi	17 200 000 000	108 000 000	6 775 000 000	7 775 000	145
North Carolina	5 229 000 000	103 411 000	.....	.....	48
Louisiana	26 588 000 000	61 882 000	21 625 000 000 (Estimated from Bulletin map.)	22 709 000	570
Georgia	16 778 000 000	272 473 000	2 500 000 000	28 335 000	64
Arkansas	.....	.....	41 315 000 000	129 781 000	319
South Carolina	5 316 000 000	124 492 000	1 000 000 000 (Estimated from Bulletin map.)	.....	50
Timber omitted as having been damaged by abstraction of turpentine	By estimation. (?)10 000 000 000	.....	.....	.....	.....
Total	127 119 200 000	1,195 158 000	101 615 200 000	335 020 000	150

The other States furnishing more or less of these pines are Tennessee and Virginia ; but it is very safe to say that if included in the statement they would actually reduce the average. From the time that white pine began to be scarce in the oldest settled States the use of Southern pine has been steadily increasing. Yellow pine, spruce and hemlock are coming more and more into use, and to the exclusion of white pine for many purposes. The long-leaved pine furnishes the tar, resin and turpentine of commerce ; and trees tapped for this purpose are estimated to lose 20 per cent. of their value for timber.

A third species, the loblolly, or spruce pine (*pinus taeda*), is found from Virginia to Florida, and west to southeastern Texas. It grows up quickly also on lands which have been exhausted by cultivation. The timber is, however, of inferior quality, and subject to rapid decay. In Texas alone the supply is estimated at 21 000 000 000 ft., b. m., and the cut at 61 570 000 ft. in the census year.

In the extreme West, the Rocky Mountains and the Sierras, are several other species of pine, of large size, and valuable for timber, but no statistics are given. Among these are the *pinus ponderosa*, growing to 300 ft. high and 15 ft. diameter ; the *pinus jeffreyi*, reaching 200 ft.

high and 10 ft. diameter; the sugar pine, largest specimens 300 ft. high, 20 ft. diameter, and 600 years old, "timber very valuable and the tree fast becoming exterminated;" and several smaller species.

O the red-wood of California there is an estimated supply of 25 825 000 000 ft., and the cut in the census year was 186 635 000 ft. The use of it is rapidly increasing.

Of spruce definite returns are given as follows:

	Supply Remaining. Ft., B. M.	Cut in Census Year. Ft., B. M.	Years of Supply. Years.
Maine	5 000 000 000	301 020 000	17
New Hampshire	1 510 000 000	153 175 000	10
Vermont	755 000 000	199 086 000	4

The New York market has drawn its supplies from these States, but it is manifest that a source more remote must soon be sought. The spruce in some of its species extends north far beyond the pine, reaching to the Arctic Ocean, near the mouth of the Mackenzie River. Its range otherwise is about the same as the white pine, and it is found in the Alleghenies as far south as North Carolina. Other species valuable for timber are found in the extreme West, extending from California and New Mexico through Oregon, Washington, Alaska, and probably to the Arctic Ocean. The timber from the spruces, firs, larches and cedars will be immense in quantity and of great value.*

The next statistics refer principally to the common hemlock. The range of this is "from New Brunswick and Northern New England westward, crossing the St. Lawrence near Quebec," and extending around the great lakes to the western end of Lake Superior.

Its southern limits are much the same as spruce, it being found in the mountains of North Carolina.

There are several valuable species of hemlock in the extreme West, growing to large size, and having a wide range of distribution.

The statistics given are of the common hemlock, and are very meager.

	Supply, ft., B. M.	Cut in Census Year.	Supply will Last. Years.
Lower Michigan	7 000 000 000	.....	..
Pennsylvania	4 500 000 000	300 000 000	15

* In Upper Michigan alone the estimate of the supply of tamarack, white and yellow cedar is 62 500 000 cords, or 95 000 000 000 ft., b. m.

The only estimates of hard wood given are the following:

	Supply in ft., B.M.	Cut in Census Year.*	Supply will Last at this Rate. Years.
Minnesota	88 473 000 000	40 800 000	2 170
Lower Michigan	883 968 000 000	520 307 000	1 700
Upper Michigan	191 232 000 000	1 145 000	....
Wisconsin	.....	155 872 000	....

In Oregon, Washington, California and Alaska there are great areas of timber of all kinds, considerable portions of which are estimated as containing 50 000 feet, board measure, to the acre, and over. Fifteen cords of hard wood, or 23 000 feet, board measure, per acre, is a good yield in the East, and one writer estimates the average yield of pine from Canada pine lands at only 2 000 feet per acre. An estimate of the average yield of white pine from two counties in Pennsylvania gave 4 000 feet per acre.

The total amount of lumber cut in the United States for the census year is given at 18 091 000 000 feet, b. m. In addition were 1 762 000 000 laths, 5 555 000 000 shingles, 1 248 000 000 staves, etc. The total consumption of wood for fuel, including about 1 000 000 cords for charcoal, is estimated at 145 778 137 cords.† This would consume all the hard wood in the State of Michigan in about five years.

A writer in the *Railway Review* says: On extra good wood lands there are 270 ties to the acre, but the average is scarcely 160.

There are now, he says, on the railroads in the United States, 335 000 000 ties, requiring 3 272 square miles to be cut over every six years to supply them, or an area equal to about two-thirds that of Connecticut.

Another writer makes the area one-third of this for heavily timbered land.

Still another estimate (by one of the Committee on Preservation of Timber) is, that there are now 200 000 miles of track in the United States, with 2 500 ties per mile, or 500 000 000 ties in use. Prof. Hough states, in a report on the "Durability of Cross Tie Timbers," that it requires 17 000 000 acres, or 26 500 square miles of forest, to furnish the present demand of the railroads in the United States for ties. This is evidently on the supposition that about 40 years are required for trees to grow to the required size.

It is estimated that a strip of land 200 feet wide along each mile of road, heavily planted with trees, would furnish this supply.

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* This is inclusive of amounts cut for staves and headings. In the case of Upper Michigan it is stated that it does not include fuel and railroad ties, and presumably this is true for the other States.

† This reduced to feet, b. m., gives 224 000 000 000 feet in round numbers, or about 12 times the amount of wood cut into lumber.

Other drains on our forests arise from farm fencing, telegraph and other electrical lines, tunneling, mining operations, piling and other engineering operations, ship building, etc.

As to notes respecting scarcity, we find remarks as follows:

Dr. Chas. Mohr, of Mobile, says: "The white oak is becoming scarce in densely settled districts. The invasion and partial destruction of large sections of forest on the lands of the government near the railroad lines through the mountains of North Alabama has been very extensive, and the supplies are getting rapidly exhausted by the constantly increasing demand."

Of the chestnut in the same region he says: "Trees of the finest proportions are ruthlessly cut down for their fruit, and the demand for its timber for fencing has also led to its extinction near the settlements. The trees would be rapidly reproduced from the quick-growing sprouts if they were not destroyed by the forest fires."

Of black walnut he says: "In Alabama it is getting scarce; fine tracts are at present destroyed (burned, I suppose he means) in districts remote from transportation."

The live oak "has almost ceased to exist as a timber resource."

The basket oak, taking the place in the South, for carriage building, &c., of our white oak, "is rapidly passing away."

The waste spoken of here is not confined to Alabama. Vast quantities of hemlock in the North have been destroyed for nothing but the bark, and in newly settled regions great quantities of wood of various kinds are burned for the purpose of clearing the land.

All these sources of waste are, however, as nothing compared with the losses from forest fires. Mr. G. L. Marler, of Montreal, says: "The Province of Quebec is being rapidly denuded of timber. Years ago the elms were burned for the manufacture of potash from the ashes. Then the pine was cut off, and afterward the less valuable woods; 'but forest fires are worse than all else.'"

Mr. Joly says: "The greatest enemy to fight is forest fires." Mr. Thistle, of Ottawa, estimates that in that region "ten times as much timber is burned as is cut." In the upper lake region the forest fires are frequently so extensive in the fall as to cover the whole country and the lakes with a dense pall of smoke for weeks. All must remember the terrible fires on the shores of Lake Michigan of recent occurrence; and in the month of April, 1884, very extensive fires ranged over a strip of country several hundred miles long in the States of North and South Carolina, nearly destroying the turpentine business over a large area in these States.*

* The total estimated loss by fires in forests in the United States during the census year is $25 462 250, but many towns and counties where fires occurred made no reports, and the loss is probably much larger than this. Of 267 fires reported in Michigan, 161 were traced to fires set in clearing land for agricultural purposes, 59 to hunters, 43 to sparks from locomotives, 3 to smokers and 1 to the Indians.

Wind storms and insects are also agents of destruction, whose ravages are not to be overlooked.

Before attempting a summary of the statistics given, it is only fair to state that other writers point to the magnificent forests yet almost untouched in Virginia, Tennessee, North Carolina, eastern Kentucky and southern Ohio, and the supplies from the southern and extreme western States; then when these are exhausted, Canada, the Valley of the Amazon, etc.; also the great areas of second growth timber in all the older States. Another important fact, and one which tends to conceal the growing scarcity in the older districts, is the paramount use of coal for fuel, almost to the exclusion of the use of wood, over considerable areas. The areas given on the map of the Forestry Bulletin show about 10 per cent. of the area settled as coal burning, 25 per cent. as burning coal and wood, and 65 per cent. as wood burning. A remark made by Prof. Hough, of Washington, is very suggestive. He says: "As the supplies of a once timbered region begin to fail, the deficiency is made up from more distant points; and so long as there are regions within reach of railways where the materials can be found for supplying the trade, we shall not realize the extent of the exhaustion until we nearly approach the end."

With this extract, let us leave the opinions of others and ask ourselves what conclusions we can reach as to the duration of timber supplies. In the light of the statistics given, we find :

1st. The supply of white pine in the United States is certain to be exhausted before the end of this century, and good judges predict the same result for the Canadian supply.

The price in the last twenty-five years has about trebled at tide-water, and there is no wood to take its place except at greatly increased cost for transportation.

2d. Of Southern pines, at the present rate of consumption, there is stated to be 150 years' supply. Even if this be greatly underestimated, the geometrical increase in the population of the country and the corresponding increase in consumption of timber, together with the immense and inevitable losses by fire, seem certain to reduce this limit.

3d. The supply of spruce in the United States, east of the Mississippi, is not fully given; but there would seem to be not over 25 years' supply. There are, however, large supplies of this and other soft woods to be drawn from in Canada and the West.

4th. Of hemlock, the supply in the East is about the same as that of spruce. It will soon be exhausted in Pennsylvania, New York and the Eastern States. The price has about doubled in 25 years, and an advance in price sufficient to warrant transportation will bring large supplies from distant points.

5th. Of hard woods, black walnut began to be used extensively less than 25 years ago, and the price has advanced to $110 per M., at whole-

sale. The supply is being rapidly exhausted. Ash has more than doubled in price, and oak, also, in the same time.

The supply of large timber in all these is destined to rapid extinction in the older settled districts. The supplies to be drawn upon are so great that we cannot predict a famine, except in some of the species. We *can* say that prices will continue to advance, as timber is brought from greater distances, and the cost of transportation is increased.

The subjoined letter, kindly written by Prof. Sargent on request, gives an interesting resume of the whole matter:

ARNOLD ARBORETUM, HARVARD UNIVERSITY,
DIRECTOR'S OFFICE,
BROOKLINE, MASS., March 30th, 1884.

My Dear Sir,—I am very sorry that I am unable to give you the information you desire.

The only estimates of standing timber made by the Census Office have been published in the various Forestry Bulletins. It was impossible to cover the various hard woods in the same manner. The only danger of a short supply in the country is confined to the white pine, spruce, possibly hemlock, and a few hard woods, such as black walnut, white ash, hickory and cherry. Of other hard woods there is still an abundant supply. Good timber is not, however, so generally distributed as formerly, and many of the older States are about stripped of all sorts, or nearly so. Great hard wood forests are now only found along the slopes of the Allegheny Mountains; in Arkansas, Louisiana, and other Southern States. A large part of these forests is inaccessible by rail, and as the oak and other heavy timbers are too heavy for "driving" down the streams, they are still saved from destruction.

The exhaustion, however, of the timber supply in more accessible regions will soon bring even the most remote of the hard wood forests into market. It will be necessary, in considering the supply of hard woods, to take into consideration the increased cost of transport from remote localities to the centers of consumption.

Yours very truly, C. S. SARGENT.

MR. F. COLLINGWOOD,
Elizabeth.

So far as we are concerned, therefore, as engineers, the matter becomes one simply of cost; and in this view alone it is evidently worth our while to economize in the use of timber.

As a matter of ethics, however, something more is due from us. It is our bounden duty to try in every way to prevent the terrible losses of timber by fire. Our locomotives are responsible for an immense amount of this mischief, and the fact is discreditable to the profession.

In cutting and burning the way for new lines through wooded countries, also, forest fires are frequently started.

In pursuit of our duty we come in contact with the backwoodsman, and we can spread sound knowledge as to the sure profit eventually to result from the preservation of the forests, and particularly of the large timber, and inculcate greater care in brush burning and the use of fire in other ways in the woods.

It is pertinent here to make a quotation from the census report respecting the supply in Wisconsin: "The annual growth of timber (in this State) is counterbalanced by the annual waste by windfalls and natural decay of old trees. The loss by fire is probably 5 per cent. of the whole. The lumbermen waste the upper part of the tree, which is not knotty but sound. From an ordinary sized tree four 16-foot logs are taken and the top log left. This is often 22 inches in diameter at the butt, and would scale from 100 to 120 feet. This is done because the pay of the loggers is small, and they cannot afford to cut the fifth log. Nearly one-tenth of the timber is therefore left in the woods and wasted.

We can also point out the profit that may be expected in many parts of the country from the cultivation of certain kinds of wood, particularly on ground which would otherwise be waste. In connection with this branch of the subject, the following notes of growth are given by various writers. These will, of course, vary with variations in conditions; and it should be remembered that the larger the tree, and the more dense and valuable its timber, the slower the growth becomes.

A sugar maple will grow to 15 inches diameter in 30 years; a white larch to about three feet in diameter in 50 years; a butternut to 12 inches diameter in 24 years; a willow to 18 inches diameter in 27 years; a black walnut to 24 inches diameter, under favorable circumstances, in 50 years, but it will not have the handsome grain of larger and older trees; a live oak grows to 30 inches diameter in 70 years; a basket oak to 42 inches diameter in 180 years; a white oak to 39 inches diameter in 200 years, and a white pine to 2 feet to 3 feet diameter in 37 years. It can be satisfactorily shown that when tree culture is intelligently undertaken in regions where timber is scarce, a fair return is made on the investment, and it begins within a few years from the first planting.

As engineers, we are called upon to study the subjects of water supply, and the effects of floods upon structures, and in causing changes in streams, etc. Now, however much opinions may vary as to the effect forests may cause by inducing local climatic changes, there can be no question as to their efficiency as conservators of the water supply of the region where they are, and of their tendency to equalize the flow of streams and prevent floods.

The public at large certainly need education upon this very important subject.

In closing this report the writer regrets that the information cannot be made more exact, but trusts that it may enable our members to form

a reasonably correct idea as to the future of the supply of timber in our country, that material upon which the success of so many of our enterprises depends.

The great unknown factor is *waste*, and we in common with all good citizens are interested in the introduction of some thorough system by which this great wrong shall be done away with. If *this* be done, and reasonable care be taken to replant forests where circumstances warrant the expectation that it can be done with profit, we may safely rely on an abundance of timber for generations to come.

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DISCUSSIONS

ON THE REPORT OF THE COMMITTEE ON THE PRESERVATION OF TIMBER; AND ON THE PRESERVATION OF FORESTS.

AT THE ANNUAL CONVENTION OF THE SOCIETY, JUNE 24TH, 1885.

JAMES B. FRANCIS, Past President Am. Soc. C. E.—Perhaps my experience in the matter may be of some interest. I commenced Kyanizing in 1848, for some corporations I was connected with, and some of the work I then did is now in existence. It was said that Kyanizing in England was a failure, and in 1848 I made a journey to England to find what the reasons were. One reason was that the parties in England who were carrying it on were cheating in conducting the process. Another was that the Bethell process had just then been introduced, and the leading engineers were taking it up, and the result was that only two or three parties were using Kyanizing, but there seemed to be no sufficient reason for it. I saw Faraday and Brunel and others interested in it and they could give me no good reason why it had gone out of use. On my return Burnettizing was coming into favor. There were some advantages claimed for it, as economy and facility in carrying it on. Strong recommendations were made that it was equally good. Competent chemists that I consulted thought there was no doubt that it was just as good; so I dropped Kyanizing and went to Burnettizing, and it took ten years to find out my mistake. Kyanizing, done before Burnettizing, was stand-

ing where Burnettizing had failed; so we went back to Kyanizing, and that has continued up to the present day. The purpose we have used it for in Lowell is for the numerous bridges on the canals, which were decaying rapidly, and the result is that the cost of maintaining these bridges is reduced to about one-half by Kyanizing. Not that it is a perfect preservative, by any means, but it has increased the durability of the wood to a great extent. I put up, in 1850, a fence of spruce around a reservoir, which is still perfect. That was about 35 years ago, and it is a perfectly good fence now; not a single piece has been renewed; it has partly decayed under ground, but all above ground is perfectly good. I think the cottonwood might be made available for many purposes by this process. I have some cottonwood preserved in that way. I do not say it is perfectly sound, but it is in good condition; whereas the unprepared cottonwood is nothing but black mold. There can be no doubt about the preservative effects in lengthening the life of wood either by Kyanizing or by Burnettizing. We have found the Kyanizing answer our purpose the best, and we have followed it ever since. My experience has been long enough to leave no doubt whatever about it; it extends from 1848 to this time. Creosoting, I have no doubt, is a still more perfect preservative, but the expense and difficulty of doing it prohibit its use here to a great extent. Kyanizing is only a preventive of rapid decay; that is all that is claimed for it; it delays the decay.

E. A. Fuertes, M. Am. Soc. C. E.—I have had some little experience in regard to Burnettizing that has led me to believe that the process is not always effective. In 1869 or 1870, the City of New York was largely under the control of Tweed, and many contracts were given out for the paving of streets with wood, and one of the contracts called for Burnettizing the blocks. Very soon after the contract was given and this pavement was laid, Mr. Tweed fell, or rather was pushed out; and there was appointed a commission to investigate his frauds. I was appointed engineer of that commission and took up the pavement. Part of it I took to Prof. Chandler to analyze the wood and see what he found. Apparently nothing had been done; no chloride of zinc had been injected into the wood. But the other side, the contractors, introduced Dr. Wurtz to testify, and he swore that not only was the wood Burnettized, but that he himself had done it. The pavement had been laid down for a year or a little over. We then had some of the blocks which had not been laid down examined and found they had been fully Bur-

nettized, and after that we took up some of those which had been laid down, and in a cart load of those, there was just a trace found of the chloride of zinc. The inference from the facts was that in the course of a year the chloride of zinc had washed out of the wood.

D. J. WHITTEMORE, Past President Am. Soc. C. E.—Some 15 or 18 years ago we unfortunately had a wooden bridge of 247 feet span burned down on a line of road I am connected with, and we were very anxious to have the bridge we should build in its place protected from decay. We therefore had the lower part Burnettized, and took upon us to see that the process then in operation was perfectly carried out. Twelve years afterward, and about six years ago, the bridge parted its lower chord, consisting of six pieces, and that was the very part that we had Burnettized. We were quite anxious to determine whether anything remained of the chemicals that were injected. We had pieces from various parts of that chord taken out and gave them to Mr. Shaler Smith, who had them analyzed, and he reported that not the least trace of the preservative chemicals was to be found in the wood.

Prof. E. A. FUERTES.—Dr. Wurtz used a three and a half per cent. solution, but the fibers of the wood were vertical, and that evidently helped considerably to the washing out of the solution.

T. EGLESTON, M. Am. Soc. C. E.—I have been somewhat surprised in listening to this very able report to hear nothing whatever in regard to the age of the wood which it was attempted to preserve, nor in regard to the time of its cutting. So far as my examination of wood, as a metallurgist, is concerned, I find it absolutely necessary to pay the very greatest possible attention not only to the age of the wood but to the time it is cut. It has been found by a series of experiments lasting some 35 or 40 years that if wood is cut during the month of January, then ranked up, and afterward used, its life may extend without any preservative whatever, in wood of proper character and age, for 15 or 16 years, whereas wood of the same species, if cut at a different age and time, may last only three or four years.

At the Cleveland Convention of this body I gave a succinct account of these experiments made by the German Government. These woods were made into wine barrels, etc., and buried in the earth for the purpose of ascertaining how far they could be used for different purposes.

I think that a part of the failures in these preserving processes can be ascribed entirely to the circumstance of the wood being cut in the

wrong season of the year. Other failures may be attributed, I think, to the fact that the wood is of improper age. It is the habit of a great many persons cutting timber to cut it at any season of the year, and I have not infrequently, in many parts of this country, been able to establish the fact that for metallurgical purposes not more than ten per cent. of the value of the carbon contained in the wood was made use of by the company that was using it. I am quite sure that if the time of cutting was taken into consideration some of these processes would be found of very great value. There are some of them, however, based upon false principles; chemically they are impossible; they could not be carried out in a laboratory on a small scale, much less on a large scale. If these processes were investigated on a large scale, as they should be, we should not have our Government paying thousands of dollars for processes entirely useless.

J. J. R. Croes, M. Am. Soc. C. E.—The inspection of the method of preparation of any timber, while the work is in progress, which is impressed so strongly by the Committee in this report, seems to me very necessary. I let a contract during this past winter for the impregnation of railroad ties with not less than ten pounds of dead oil to the cubic foot. I required the contractor to notify me when and where the process was to be applied. I received notice one day that two days later the timber would be creosoted in North Carolina. I insisted upon delay in the matter, and sent an inspector immediately to the creosoting works, who found that this timber which was to be impregnated with ten pounds of dead oil was, at the mills where it was cut, first put for two or three hours into a cylinder and heated, and then put into an open tank of oil which they said was dead oil, and there lay for three hours, being turned over with a pike pole, and was then shipped on board a schooner. This dead oil was cold when they put the timber in and cold when they took it out after three hours. They said there was ten pounds of oil in. I sawed one of the sticks in two and found it discolored about an eighth of an inch from the surface. Of course, I did not take the timber, and I found it could not be properly impregnated at that place or by that process, especially as the oil used was not dead oil, but was chiefly a product of the distillation of pine wood. They claimed that it was better than creosote. I found that the only place the work could be done conveniently was in New York. The timber, North Carolina pine, was shipped to New York and was impregnated with dead oil at creosoting works in Brooklyn. The

requirement in most of the authorities is that there should be not less than ten pounds of oil to the cubic foot, but I found on further examination that it depended very much on the size of the stick how much oil was necessary for its preservation, that it took thirty pounds of oil to the foot to impregnate timber throughout, and that it took from forty-eight to sixty hours in the charging chambers to impregnate ordinary timber to that extent. After the timber has been put into the cylinder and steamed, and all the moisture driven out in that way, and then the oil put in under pressure, ten pounds of oil will go in in the course of five or six hours into timber 8 by 8 or 6 by 6; but to put in twelve pounds of oil takes several hours more, to put in fourteen pounds takes still longer, while to put in sixteen or twenty pounds takes several hours longer, which increases the cost very much, the cost being dependent in a very great measure on the length of time the operation takes. I found on cutting these sticks that when there was ten pounds of oil it penetrated about a foot into the ends of the sticks, and it went in about half an inch into a stick 8 by 8; that is, the timber, when it was sawed in the middle, showed the presence of the oil about half an inch deep. For railroad ties which were to be put on iron girders and notched from half to three quarters of an inch, according to the adjustment of the grade, on an iron trestle, it did not seem to be safe to take ten or twelve pounds, because in the harder portions of the stick the oil went in barely a half inch, in some cases not quite so much. So I had fourteen pounds of oil put into the timber, in which case it went into the softer parts one and a half or two inches, while in the harder parts it went in a little over half an inch as a general thing. I have preserved sections of the sticks which were impregnated with different quantities of oil, all cut from the same stick of timber. Pieces about 5 feet long were put into the machine, and then sections about two inches thick were taken from the middle of these pieces, which showed just how the oil penetrates the wood and how necessary it is to make the quantity of oil dependent upon the area of the sticks, or rather on the periphery of the stick. The oil goes into the end of a stick some distance, but to preserve the stick, especially if it is to be cut, it must enter into the wood on the side for a certain distance, according to the use the timber is to be put to. It is evident that a stick of twelve or sixteen inches square will not need as much oil as a six-inch stick. The smaller the stick, to get the requisite amount of penetration of the oil—that is, to have the wood preserved to a requisite distance

from the outside in—the greater the proportion of oil to the cubic foot which is necessary. Therefore I don't think there is any absolute rule to be applied in regard to the amount of oil to be used for impregnating. It ought to be made dependent upon the depth of the stick to which you want the oil to penetrate, and then by actual experiment in each case find what amount of oil it takes to penetrate that distance. For a pile 12 or 14 inches in diameter, to thoroughly protect it from the teredo, it was stated by the operator that it was necessary to thoroughly saturate it, which takes about thirty pounds of oil to the cubic foot of North Carolina pine.

J. F. Flagg, M. Am. Soc. C. E.—Do I understand that with a larger stick you need more oil?

Mr. J. J. R. Croes.—No, the larger the stick the less oil to the cubic foot is required to impregnate the periphery to a given depth.

Charles Latimer, M. Am. Soc. C. E.—I have listened to this report with a great deal of interest, and I think it the clearest and most valuable paper I have heard on this subject. It has gone into the matter very thoroughly, and the Committee deserve the thanks of the Society and the public. There are some facts probably that it would be well for me to state, inasmuch as my experience gives me the right to mention them, and it would be well that they should go on record. In relation to the life of timber, I have had a very fair opportunity of judging what the life of ties should be in eleven years of experience on one road in which I had the entire charge of purchases of all kinds. We have 800 miles of road. That will give us 2 000 000 of ties. In the time mentioned we bought something over 2 200 000, so that every tie, or nearly every tie, had decayed in that length of time. The life of ties of oak, which are the most of our ties, is eight years; in bridges, nine years. Now, that statement in relation to the value of ties is quite important. Eleven years ago we paid 50 cents for ties; to-day we are paying 45 cents per tie. Although the contractor says each year it is impossible to get the ties, he manages that we can get without difficulty just as many as we want, and now, not, I suppose, that I would be unable to get them from along the line, I am going to Michigan, where I can get cedar ties delivered for 40 cents. I want to state facts which may be of value to correct any statement or misapprehension in relation to timber. The facts are important in that regard. In relation to the wear of timber, I know of timber which I saw taken up. I know where it was brought from positively, as

I have the witness of very responsible parties; it was planted in palisades, stockades. It is seventy years old and perfectly sound. I refer to the catalpa tree. I planted some of those trees, but they gave me the wrong seed, and now in five years I have got a lot of scrub trees which ought now to be ties, but they are only three or four feet high. Coming to the question of preparing ties, I have had a little experience. I bought 20 000 Thilmany process ties. I bought them delivered at Mansfield for fifty cents per tie ; the process of preparing them cost 15 and 20 cents a tie. I thought I had a very good bargain, and I congratulated myself upon getting a set of ties that would last me a very long time ; but I am sorry to say that the report of the Committee is entirely borne out in the later examinations of those ties, as we find they are mere shells. Therefore, my experience with ties preserved by the Thilmany process is entirely unsatisfactory. I have no other experience in the preserving of ties; but the facts that I have given bear upon the question, and it seems to me are important.

Mr. JAMES B. FRANCIS.—There is one matter alluded to in this report which I did not speak of, and that is the poisonous nature of Kyanizing. We never found the slightest trouble with it in that way. Since 1848, with an interval of perhaps ten years, there has been no case where the men operating in it have been made ill. Once in a while the men working over the tank where the material was dissolved in hot water have complained somewhat of it, but I never knew any man made seriously ill. The men go into the tank with bare feet, and it seems to be rather healing to cutaneous diseases. The only danger seems to me to be from the efflorescence on the surface of the wood. The timber sometimes becomes white on the outside from the salt in it, and that might be licked off by cattle. The white substance on the timber is corrosive sublimate. That is very poisonous, but as to the process we have had no trouble whatever.

Mr. J. J. R. CROES.—I would like to ask from the Chairman of the Committee what there is to be said about a process that I do not see mentioned in the report, the process of wood vulcanizing, as it is called, or subjecting the wood to heat in some way, and converting the sap into rosin and hardening the wood so that it is claimed that it will last forever when used for railroad ties or for any other purpose.

Mr. CHARLES LATIMER.— Iwant to say that if any process can be obtained which will double or add 50 per cent. to the life of ties, using the

cedar or the hemlock, of course there is an immense economy in it, and I trust that some one has that process, for it would pay us to use it. I can get cedar ties from the northwest at 35 cents, and hemlock ties at 30 cents on the road, so if ties were to be preserved and cost no more than 50 cents, and would last 15 years and hold a spike well and not become brittle, it would certainly be very valuable.

Prof. T. EGLESTON.—So far as my experience goes in making investigations on woods, any process whatever which causes any chemical change to take place in the substance of the wood makes the wood brittle. The moment there comes to be any change in the color of the wood from heat, the wood becomes entirely unfit for constructive purposes. Almost all these processes have in view the production of acetic acids. If the process is carried so far as to give an acetic acid, the wood is not good for anything. If the process is not carried so far as to get good acetic acid, the acetic acid commands a very small price, and the wood is not good for anything but kindling.

A. W. LOCKE, M. Am. Soc. C. E.—One point I do not hear alluded to in the report of the Committee, and that is the cost of removing old ties from tracks or bridges and replacing them with new, which would have a very favorable effect upon the figures given by the Committee. I have observed that the cost of replacing ordinary ties after they are delivered on the ground is about 10 cents per tie year by year. That would have to be taken into account, and would probably be 25 per cent. of the amount of saving effected. Then in replacing ties upon bridges it will cost one or two dollars per lineal foot of bridge to place ties upon bridges where traffic is being carried on.

Mr. EDWARD P. NORTH.—Some wooden pavement was laid on Fifth avenue, between Thirty-second and Thirty-third streets, about a year ago. The wood was brought from England already "creosoted." There was very little creosote in the wood, and I brought some to the Society room that smelled more decidedly of the pine than of the creosote on the outside of it. Horace Loomis, M. Am. Soc. C. E., Assistant Engineer to the Department of Public Works, has a specimen in his office that is noticeably free from creosote, I think that must have been creosoted as Mr. Croes' North Carolina pine was. When that wood pavement fails it will probably be cited as a proof of the uselessness of creosoting. A surveyor in London, who was laying a wood pavement on Brompton Road, told me that creosoting was of no use, that the "dipping"

was not worth anything; and as many English engineering publications speak of the necessity of having wood dry before creosoting, it is possible that dipping in hot oil is resorted to instead of the more thorough methods generally in use in this country. At any rate, in case of creosoting or any other process proving a failure, the method employed should be investigated and given with the record of a failure.

Prof. E. A. FUERTES.—Prof. Egleston mentioned something in reference to the amount of carbon depending upon the age of the wood. I would like to know if he has made any experiments as to the amount of carbonates in the wood, or rather as to what functions they have in the wood.

Prof. T. EGLESTON.—I cannot remember the figures, but where the wood is cut after the sap rises it is so porous that it will not bear any weight, and so when I said that not more than ten per cent. of the carbon was contained in the wood, I did not mean that the carbon had undergone any change, but the material was so porous that it would not stand the weight of the charge in the furnace, and had to be thrown away.

Mr. CHARLES LATIMER.—Mr. Crowell is here, and he has been over to Europe and saw some steel ties there. The question is if we may use the steel with economy. He has seen steel ties in use there, and he knows their cost. The question is whether we can afford to use the Burnettized and creosoted ties in comparison with the steel ties.

Prof. T. EGLESTON.—In 1869 Mr. Krupp told me that he never should use another wooden tie. In the year 1882, and last summer, I made a special trip to Europe with reference to testing this question of steel ties and their manufacture. It is known now in Germany that it is cheaper for them to lay down steel ties made by the Bessemer process than to use wooden ones. The large works there are turning out now basic Bessemer steel ties whose life has been determined to be so long, whose extra stability in a permanent way has been found to be so great, that they are being sold all over Germany. In the North Western Steel Works, in the North of England, they are already making these steel ties, and I think in time the steel ties will very largely supersede the wood ties. I will ask Mr. Crowell to state his experience.

J. F. CROWELL, M. Am. Soc. C. E.—I will not occupy the time of the Convention at any length. What I saw of the metal ties would not be of special interest here, I think, but it convinced me of the entire practica-

bility and adaptiveness of the most improved tie used in those German roads that I examined. In regard to the cost, the late Mr. Lorenz, of the Reading Railroad, procured several specimens of the ties, and made an estimate with the object of introducing them on the roads he was then connected with, and he found, if I remember correctly, that the price would be in the neighborhood of $7 000 per mile; that is, for the ties only, for say 3 000 ties per mile, which would be a large cost compared with the first cost of the wood ties. The wearing of the steel ties might be three or four times as great as that of the wooden ties, and that added to the saving of replacing the wooden ties would probably reduce the cost at the end of the life of the steel ties to something less than the cost of the wooden ties. The cost he figured was the duty added to the cost of the steel tie which he could then buy in Germany. If steel ties could be brought down somewhere near the price of steel rails, the tie weighing one hundred and ten pounds would perhaps cost $1 50 in round figures, as against the average cost of the wooden tie. The initial cost, however, is not a fair test of the value of a permanent steel tie. If we can get a tie that will not deteriorate, and which can be relied upon to stay in the track without so much work, the economy of a high-priced tie would, perhaps, be very great. In Germany they have experimented with a number of different forms. The particular form that I saw in use was the latest. It was simply a channel extending with its flanges into the ballast and with a very simple fastening. Bolts were used in the fastening to connect the rail with the tie, and that is a form we would probably find objectionable. They do not seem to find it so there, but we have a good deal of trouble with four bolts to the rail, and with fifteen or sixteen more the matter of the bolts would be a serious question. But if we can get a simple tie of that form with a secure fastening, which will not require too much attention to keep in good condition, I think the economy in substitution, even at the present time, would justify its use in many cases.

F. Collingwood, M. Am. Soc. C. E.—By request of the Chairman of the Committee I took up the subject of the question of cost, and have written very briefly upon it.

The report gives in the appendices three different methods of estimating the economy to be derived by using some process for preserving ties. That by Mr. Andrews gives the money saving at the end of the term of life of the preserved tie. That by Mr. Harrod, the life that the preserved tie must have in order to make the cost of using preserved or

unpreserved ties equal. That by Mr. Welch, the money value of any tie in use when compared with the white oak unpreserved tie taken as a standard; the difference between this money value and the cost showing the economy or loss in use.

In the first and last of these investigations the authors have compounded the interest on the several costs; in the second case simple interest only has been taken. This is a point that must be settled before any close agreement can be reached in the discussion. While theoretically it is correct to use compound interest in all computations of this kind, practically the results are often misleading. Wherever the interest remains in hand, and is reinvested as principal, as in the case of Savings Institutions, or Life Insurance Companies, the interest can be compounded, but even then all expenses for management or losses of any kind must be deducted annually; so that in very few cases is full compound interest ever realized, that is, interest compounded at the full legal rate.

Now, railroads are not lenders but borrowers. Their accounts show each year a large amount paid on interest account, and, as a prominent item in working expenses, renewals of ties. Compound interest never figures there, and even if there be a renewal fund on interest, the interest is spent each year and cannot be compounded. "You cannot eat your cake and have it too."

In making comparisons it is necessary, also for fairness, to compute interest on all sums paid out to the end of the term of life of the longest lived tie; otherwise interest will be charged at the end of the shorter life on the interest which has accumulated on the difference in first cost. This tells against the longest lived tie, and makes Mr. Andrews' method not quite fair to himself.

By his suppositions and methods (using simple interest), the saving per mile by creosoting is $3 086.10, but by taking interest on the one side on $2 340 for 16 years, and on the other on $2 080 for 16 years, and $2 470 for 8 years, the actual saving is shown to be $3 146, or 151 per cent. on the cost of first laying of the cheapest tie.

Table No. 1 following gives a few results worked out by this method. By this it seems that the rate of interest paid makes no material difference in the percentage of economy obtained by preservation of ties. As the cost of ties increases, the economy increases rapidly. As the cost of preservation increases the economy diminishes rapidly.

On the supposition that an unpreserved tie before laying cost 40 cents, first laying 15 cents, and renewals 15 cents more (or a total of 55 cents in new track, and 70 cents when in old track), and that it will last 5 years; also that a preserved tie will cost 25 cents more and last 12 years, with interest at 6 per cent.; this table (see No. 7), shows a saving per mile every 12 years of $2 400, or 169 per cent. on the cheaper tie. If the life of the preserved tie be 16 years, according to European experience, the saving per mile will be $4 700 (see No. 5).

If a preserved soft wood tie with life of 12 years cost 75 cents in new track, and an unpreserved oak tie will last 8 years and cost 80 cents, then the saving per mile will be $2 050 (see No. 11), or about the same as the cost of the oak ties.

As there are now in round numbers 500 000 000 ties in use in railroads in the United States, if these were all of oak, the saving by substituting preserved soft wood ties under the last conditions would be about $410 000 000, or $34 000 000 per year.

If a preserved oak tie costs in new track $1.05 and lasts 16 years, and the same unpreserved costs 80 cents and lasts 8 years, the saving per mile will be about $2 400 (see No. 14), or on all the railroads in the United States about $30 000 000 per year.

These figures are given to illustrate in a familiar way the very great importance of the subject as an economical question. The share capital of all the railroads in the United States in 1884 was, according to Poor's Manual, $3 708 060 583, and the net profits $336 911 884. Hence, if such a saving can be made, it will pay nearly 1 per cent. per annum on the share capital, and about 10 per cent. on the net profits.

Table No. 2 is computed by Mr. Harrod's method; a column of results, according to his method, is also added to Table No. 1. It will be found by comparison that its results are not quite as favorable to the preserved ties, the differences being due to slight variations in the interest account.

The difference between the figures in the last column of Table No. 2 and the actual life of the preserved tie in each case shows the measure of economy by its use. The first method is the most direct of all.

Mr. Welch takes the unpreserved oak tie as a standard, and determines the value of any other tie by taking account of its first cost and the interest accumulating during its life. The difference between the value by formulæ of the tie under examination and its first cost

gives the gain or loss by its use. When used with simple interest, the formulæ give anomalous results, as will be seen by the last two columns in Table No. 3.

The incompatibility of results by these formulæ, when compound interest is used, is shown by reference to that part of the appendix where a comparison is made between ties "for their own lifetime." Taking the first case there mentioned, the various results can be put in the form of an equation, which will be seen to be identical, thus:

$$\frac{0.41 \times 2.09 - 0.41 \times 0.80}{1+0.41} + \frac{0.80 \times 0.41}{1+0.41} = \frac{0.41 \times 2.09}{1+0.41} = \frac{a' v}{1+a'}$$

In other words, the result arrived at for the true value of the cheaper tie is nothing more than the present worth of the interest which would accumulate during the first term T', on the value of the indestructible tie. In the case of the hemlock tie, this becomes:

$$\frac{2.09 \times 0.272}{1+0.272} = 0.447$$

If, however, we make the comparison for the second half of the life of the oak tie, we have to take account of the interest which has accumulated during the first half, and the oak tie must be charged with a capital of $v + \$0.568$. We get for the second term, therefore, a present worth of:

$$\frac{0.272\ (2.09+0.568)}{1+0.272} = 0.568$$

or the hemlock tie worth 12 cents more than cost $(0.57 - 0.45 = 0.12)$.

It is manifest that C W and R will each be increased by the same amount when considered as applying to renewal ties, as in the case of relaying an old track, and the results by the formulæ will not be changed.

TABLE No. 1.

COMPUTED BY THE FIRST METHOD INDICATED ABOVE, COUNTING 2 600 TIES PER MILE, WITH A COLUMN ADDED FOR COMPARISON WITH RESULTS BY HARROD'S METHOD.

Number.	Kind of Tie.	Rate of Interest.	Life of Ties.	Cost of each Tie in New Track.	Cost per Mile of New Track.	Cost per Mile of Renewals (at 15 cts. each additional).	Cost of Preserved Ties at end of Life.	Cost of Unpreserved Ties for same length of time.	Saving per mile by use of Preserved Ties.	Per Cent. of Saving on Cost of first laying of Unpreserved Tie.	Time that highest-priced Tie must last to be of equal value with the other, as given by Harrod's Formula.
			Years.								
1..	Preserved soft..	6 per cent.	16	90 cts.	$2 340		$4 586 40				
	Oak.....		8	80	2 080	$2 470		$7 732 40	$3 146 00	151	$9\frac{31}{100}$ years.
2..	Same	5 "	16	90	2 340		4 212 00				
			8	80	2 080	"		7 202 00	2 990 00	144	9^{23} "
3..	Preserved soft..	6 "	16	80	2 080		4 076 80				
	Soft.....		8	55	1 430	1 820		5 496 40	1 419 60	99	13^{19} "
4..	Same	5 "	16	80	2 080		3 744 00				
			8	55	1 430	"		5 122 00	1 378 00	91	12^{87} "
5..	"	6 "	16	80	2 080		4 076 80				
			5	55	1 430	"		8 772 40	4 695 60	328	$7\frac{52}{100}$ "
6..	"	5 "	16	80	2 080		3 744 00				
			5	55	1 430	"		8 216 00	4 472 00	313	7^{19} "
7..	"	6 "	12	80	2 080		3 577 60				
			5	55	1 430	"		5 990 40	2 412 80	169	7^{02} "
8..	"	5 "	12	80	2 080		3 328 00				
			5	55	1 430	"		5 655 00	2 327 00	163	7^{15} "
9..	"	6 "	12	75	1 950		3 354 00				
			7	50	1 300	1 690		3 950 14	596 14	46	11^{52} "
10..	"	6 "	12	75	1 950		3 354 00				
			5	50	1 300	"		5 514 60	2 160 60	166	7^{32} "
11..	Preserved soft..	6 "	12	75	1 950		3 354 00				
	Oak.....		8	80	2 080	2 470		5 405 40	2 051 40	99	7^{32} "
12..	Same	6 "	12	75	1 950		3 354 00				
			7	80	2 080	2 470		6 062 88	2 708 88	130	6^{42} "
13..	"	7 "	12	75	1 950		3 588 00				
			7	80	2 080	"		6 455 98	2 867 98	138	6^{42} "
14..	Preserved oak..	6 "	16	$1 05	2 730		5 350 80				
	Oak.....		8	80	2 080	2 470		7 732 40	2 381 60	114$\frac{1}{2}$	11^{52} "
15..	Same	7 "	16	1 54	4 004		7 927 92		129 22	6 per ct. in favor of unpreserved.	25^{25} "
			8	80	2 080	"		7 798 70			
16..	Preserved soft..	6 "	12	90	2 340		4 024 80				
	Soft.....		5	65	1 690	2 080		6 942 00	2 917 20	173	$7\frac{52}{100}$ "

TABLE NO. 2.

COMPUTED BY HARROD'S METHOD WITH A CONSTANT PRICE FOR UNPRESERVED TIES, AND AN INCREASING PRICE FOR PRESERVED TIES.

No.	KIND OF TIE.	Rate of Interest.	Cost of each tie in New Track.	Cost per Mile of New Track.	Cost per Mile of Renewals (at 15 cts. in addition).	Life of Cheapest Tie.	Yearly expenses.	Investment required to produce this amount.	Last Item + First Cost of Cheap Ties = "fixed sum."	"Fixed sum" Less First Cost of Preserved Ties.	Annual Interest on this Balance.	Number of Preserved Ties this will lay in renewal each year.	Time Preserved Ties must last to make both kinds of equal value.
18..	Preserved	6 per cent.	.80	$2 080	$2 470							At 95 cts. ea.	
	Unpreserved		.55	1 430	1 820	5 years.	$364	$6 066 67	$7 496 67	$5 416 67	$325 00	342 11	7.60 yrs.
19..	Same	"	1.00	2 600	2 990							At $1 15 ea.	
			.55	1 430	1 820	"	"	"	"	4 896 67	293 80	255 50	10.18 "
20..	"	"	1.20	3 120	3 510							At $1 35	
			.55	1 430	1 820	"	"	"	"	4 376 67	262 60	194 52	13.88 "
21..	"	"	1.40	3 640	4 030							At $1 55	
			.55	1 430	1 820	"	"	"	"	3 856 67	231 40	149 30	17.42 "
22..	"	5 per cent.	.80	2 080	2 470							At 95 cts.	
			.55	1 430	1 820	"	"	7 280 00	8 710 00	6 630 00	331 50	348 95	7.45 "
23..	"	"	1.00	2 600	2 990							At $1 15	
			.55	1 430	1 820	"	"	"	"	6 110 00	305 50	265 65	9.79 "
24..	"	"	1.20	3 120	3 510							At $1 35	
			.55	1 430	1 820	"	"	"	"	5 590 00	279 50	207 04	12.56 "
25..	"	"	1.40	3 640	4 030							At $1 55	
			.55	1 430	1 820	"	"	"	"	5 070 00	253 50	163 55	15.90 "

An indestructible tie on basis of No. 25 is worth $3.35 = $8 710
2 600

At 7 per cent. " " " 25 " 2.55
" " " 18 " 2.88

TABLE NO. 3.

Computed from Mr. Welch's Formula (at simple interest).

No.	Rate of Interest.	T	T'	a	a'	W	L	V	L'	R	C	Loss on each cheaper Tie.	Loss by First Method (for comparison).
26..	7 per cent.	7 yrs.	5 yrs.	.49	.35	$0 80	$0 80	$2.433	$0 65	$0 57½	$0 65	7½ cts.	$331 50 or 9$\frac{1}{10}$ cts. ea. for each cheap tie used.
27..	6 "	7 "	5 "	.42	.30	"	"	2 70½	"	53½	65	11½ cts.	325 00 or 8$\frac{2}{10}$ " " "
28..	6 "	8 "	5 "	.48	.30	"	"	2 47	65	30	65	35 cts.	741 00 or 18 " " "
29..	7 "	7 "	3½ "	.49	.24½	"	"	2 43	45	60	45	Gain ea. 15 cts.	100 45 or 2 " " "
30..	6 "	7 "	3½ "	.42	.21	"	"	2 70½	"	56½	45	Gain ea. 11½ cts.	123 50 or 2½ " " "
31..	6 "	12 "	5 "	.72	.30	"	95	2 12	70	21	55	Loss ea. 76 cts.	2 412 80 or 39 " " "
32..	6 "	16 "	8 "	.96	.48	1 05	1 20	2 30	95	32	80	Loss ea. 68 cts.	2 381 60 or 46 " " "

DISCUSSION
ON THE PRESERVATION OF FORESTS.

C. J. H. WOODBURY, M. Am. Soc. C. E.—In the State of New Hampshire, with a view to encouraging the growth of trees along the public highways, they have a law which gives a modification of taxes to those putting up drinking troughs for live stock or planting trees along the highways. Wherever that has been done it was in the most perfunctory way, merely enough to cover the law.*

A few years ago my attention was called to the catalpa as a tree furnishing a source of lumber which resisted decay. I procured some seeds of the *catalpa speciosa* from Dayton, Ohio, and planted them in Northeastern Massachusetts in 1879. Those trees have now reached the height of nine feet. I had 100 of them, but when they were about four feet high an over-vigilant gardener weeded out most of them, but the remainder are growing well and are in a flourishing condition, and I hope to see them to the size that the tree grows in the Middle States. Some were planted on alluvial soil; some on high, rocky and naturally sterile ground. That is, as far as I have been able to learn, the most northern growth of the catalpa tree. If I may be permitted to allude to the interesting report of the Committee on Preservation of Timber, presented last night, as far as the report of that committee has gone, the use of lime upon timber subjected to the direct dampness of the earth, water, or what is worse, alternate wet and dry, was not successful, and yet the experience of every one of us shows that under other conditions lime is a preventive of decay, especially against dry rot, as long as the wood is not subjected to conditions which remove the lime. Who ever knew a lath to decay? As an instance of the efficiency of lime in the preservation of wood against decay, I may cite the case of a mill in Claremont, N. H., where the basement was blasted out of a very seamy ledge, through the fissures of which there came a great deal of water, either by springs or infiltration from the canal. It was blasted out to the depth of two feet below the floor, and the stone chips replaced to within four or five inches to the grade of the floor. As it came nearer to the top of the stone filling, finer and finer stone was selected, and upon that lime, gravel and air-slaked lime, and then the spruce was laid directly upon the lime. That was in 1856. Last spring I was at the mill when

* See note at the end of this discussion.

repairs were being made, and found that the under side of those planks was penetrated by dry rot to the distance of an eighth of an inch, showing that the use of lime had served to protect the floor against dry rot for twenty-nine years, under exceptionally difficult circumstances. The use of wire lathing has been carried on for many years, chiefly as a protection against fire. The earliest use of it was in Paris in some of the buildings erected under the administration of Bonaparte as First Consul, which I have been informed are still in sound condition. At the Boston Theater, in a place where dry rot might be expected, around large spaces in the decoration, where such lathing was put on in 1853, an inspection of the timber work, back of the lathing, last year, showed it to be in a thoroughly sound condition. It seems to me that the effect of dampness is rather more deleterious to wood than running water, for I have seen wheel pits of mills where the ends of the timber against wet ledges would be sound, while further up, where it was subjected to dampness rather than to the direct application of water, signs of very rapid decay were shown. In the matter of the preservation of timber, a great deal of it decays because it surrounds a confined air space. I have known the basement floors of mills within four feet of the ground to show signs of sweating in a very few days when the air was confined, but when the air space was open and a circulation of air forced under the mill, the timber dried and the dry rot was stopped entirely. The ventilation of timber is a very important phase of its preservation, and much of the decay of timber would have been prevented, if due care had been exercised in the protection of ends exposed to the weather, and the ventilation of confined spaces.

NOTE.—Since the meeting I have had a search made among the statutes of the States, and learn that the legislation on this subject seems to be directed into three classes; nineteen States have protective laws, which, by the enactment of severe penalties upon those who injure trees, defend the owner to an extent wholly beyond the remedy furnished by the common law; the second class, comprising seventeen States, have subsidizing laws, which still further encourage tree cultivation by direct bounties and abatement of taxes, in addition to defenses against trespassers; the third class are without legislation on the subject, and include the seven States of Florida, Kansas, Louisiana, Maryland, North Carolina, Texas and Washington.

Kansas had a law containing provisions for giving bounty to persons for planting trees (General Statutes 1868, chap. 112), which was repealed (Laws of 1874, chap. 76).

Texas has a law which gives a railroad corporation permission to cut timber where it chooses.

Of the States with protective laws which purpose to defend trees already grown rather than to encourage the planting of trees, Alabama (Code 1876, §§ 4425–4428; Statutes 1879, No. 137; 1885, No. 64) is chiefly devoted to the protection of the pine forests in the turpentine interest; also prescribing penalties against destroying ornamental trees and setting fire to forests.

In Arizona the provisions (Code 1877, p. 96) refer to injury to shade trees. In Arkansas (Digest 1884, §§ 1658–1660; also §§ 1956–1959) the laws prescribe penalties for cutting timber, and setting fire to forests. Connecticut (General Statutes 1875, title 19, chap. 17, § 7) has penalties for cutting and destroying trees. Dakota (Code 1883, §§ 704, 708) makes the penalties cover malicious injury to timber, fruit or ornamental trees. In Delaware (Revision 1874, p. 777) the law indicates the nursery interests in the State by fixing the penalty for *taking* ornamental or fruit trees. Stealing a tree, and not a portion or product of it, seems a novel theft, and certainly would not occur except around nursery gardens.

The laws forbidding injury to timber and ornamental trees in the following States contain provisions which are, on the whole, quite similar to each other in the desire to protect a person in whatever he chooses to do in the way of tree planting. The references are as follows:

Georgia, Code 1882, §§ 4440, 4615. Indiana, Revised Statutes 1881, §§ 1928, 1961. Minnesota, Statutes at Large 1873, pp. 885, 994, 1003. Mississippi, Code 1880, §§ 961–965. Montana, Ohio, Oregon, Pennsylvania have numerous laws on this subject. South Carolina, General Statutes 1882, §§ 1167, 2501, 2512. Tennessee, Code 1884, §§ 5403, 5425. West Virginia, Revised Statutes 1878, chap. 41, § 28. Virginia and Wyoming complete the list.

The elaborate provisions in the laws encouraging arboriculture are followed by conditions which require that the bounties must be *earned*, and give rise to the presumption that in some instances such laws were drafted by enthusiasts, and amended by practical politicians. The estimate of the value of tree planting to the community is widely different in various States, and the amount of the bounty may be taken as an index of the popularity of such legislation.

California recognizes the value of trees along the highways, by making it obligatory upon the County Supervisors to encourage road-side cultivation and pay to the planter $1 for every living tree 4 years old (see Code of California, §§ 13, 384, 2755 and 4080). Colorado (Code 1883, §§ 3425, 3426) has enacted the peculiar provision that the planting of trees shall not increase the assessed value of land until 10 years after planting; and that an annual premium of $2 for every 100 trees shall be paid from the fourth to the tenth year after planting.

Idaho, in the Act of January 4, 1875 (Revised Laws, page 712) goes

even further, and exempts from taxation for a term of 10 years tracts of planted trees over 5 acres in extent.

Illinois (Revised Statutes 1880, chap. 136) permits county boards to offer a premium of $10 per acre. Iowa has elaborate provisions, allowing partial remission of taxes on forest plantations (Rev. Code 1880, §§ 798, 3889, 3899, Acts 1880, chap. 190).

The laws of Maine (Revised Statutes 1881, p. 144) show that the immense lumber interests of that State are beginning to feel the effects of indiscriminate felling of native forests, as their present laws exempt from taxation for 20 years land containing 2 000 forest trees planted on each acre. In the great lumber State of Michigan, the bounty is framed for the encouragement of tree planting along the highways (Statutes 1882, § 1408, 1410, 9129, 9171, 9173, 9174, 9193, 9405, 9407).

The Commonwealth of Massachusetts allows towns to raise money to plant shade trees (Public Statutes, chap. 27, § 12), and also encourages growth of ship timber (chap. 114, § 8), and exempts timber plantations from taxation between the fourth and tenth years. Missouri (Revised Statutes 1879, § 5697) fixes the forest bounty at $2 per acre for 15 years. Nebraska gives a bounty of the compromise sum of $3.33 per acre, and limits the application of the payment to plantations of 3 acres. Also compels towns to plant shade trees, and levies special taxes therefor (Compiled Statutes 1881, p. 52).

The laws of Nevada (Compiled Laws 1872, §§ 3838, 3842; Statutes 1877, chap. 113) are similar to those of Colorado, in limiting taxation and giving bounties.

In New Hampshire the towns may raise money to set out shade trees, and abate taxes to persons who do so (Gen. Laws 1878, chap. 37, § 9; chap. 281, § 3).

His Excellency the Governor of New Jersey is authorized by the Act of February, 1884, to set apart a day in each year for planting forest trees.

New Mexico (Compiled Laws 1884, § 2809) offers exemption from taxes similar to those of other States.

New York abates highway tax to persons planting shade trees along the roads (Revised Statutes, 7th Ed., pp. 1263, 1235, 1257, 2208, 2517, 2527, 2483).

Rhode Island exempts forests plantations of 2 000 trees to the acre on land worth less than $25 per acre, for 15 years after the trees are 4 feet high. There is not much land within the boundaries of this thickly-settled State, and the amount, whose low value renders it eligible to enter into this competition, must be relatively smaller than in any other State. The State of Wisconsin (Statutes 1871, Title VI, chap. 19, §§ 166-168; Title XIII, chap. 77, §§ 32-36) contains elaborate provisions framed to encourage tree planting.

MENDES COHEN, M. Am. Soc. C. E. (Chairman of the Convention)—I may say that further discussion of the question of the preservation of timber is quite open. If any remarks are to be made on that subject in connection with the subject of the preservation of forests, the Convention will be glad to hear them.

JAMES B. FRANCIS, Past President Am. Soc. C. E.—In reference to planting timber, the cottonwood we all know is a very rapidly growing timber, but it decays very quickly. According to my experience, it can be preserved from decay as well as any other wood. I have a cottonwood post in the ground twenty-three years, and it is well preserved yet. If timber is to be planted and cottonwood can be made useful for timber by treatment, it would be worthy of extensive cultivation. It is a rapidly growing timber and can be made a good timber for many uses. It would seem to be worthy of cultivation on the prairies. In ten years, I suppose, probably less, it would be large enough for many railroad purposes. As I said before, I am confident that it can be preserved from rapid decay as well as any other wood.

J. F. FLAGG, M. Am. Soc. C. E.—What do you think of the comparative strength of cottonwood and white pine?

Mr. JAMES B. FRANCIS.—I suppose it is very inferior to white pine; but then it grows so much more rapidly, say in 10 years instead of 100, and it has strength enough for many purposes.

Mr. F. COLLINGWOOD.—Mr. North spoke of the growth of pine taking so long a time. Those who have ever read closely the proceedings of the Forestry Convention of Montreal cannot help having been struck by the fact that it is possible to make a forest begin to pay its way quite soon anywhere within reach of a market by not waiting for the timber to grow to a size for use as timber, but planting quite thickly and gradually thinning out.

The various writers do not recommend that the choicest farm lands shall be devoted to tree planting, but the many waste places, hillsides, etc., to be found on almost any farm; also a strip of land on the north and west to ward off the cutting winter winds. Various experiences are given showing profits realized annually per acre (after paying rent) of $1.25 up to $50 in an extreme case. The first sum was on land valued at $20 per acre. The returns begin to come in after 5 to 8 years.

The governing principle in forest culture seems to be that the foliage shall at all times be dense enough to protect the soil from the drying

effect of the sun and winds. As a result of this, the trees grow mostly upward; the lower limbs die or are cut off before they become large enough to cause bad knots, and the subsequent annual rings are clear and straight. Thinning begins when the wood is large enough for hoop-poles (if the wood be suitable), then hop-poles, small masts, stanchions, mine timbers, fuel, etc., being carried on systematically, with a due regard to the principle first mentioned.

T. EGLESTON, M. Am. Soc. C. E.—The experience I have had with timber has been mostly with regard to its use as fuel. It has been shown by long experience in the forestries of Europe that it is quite possible for the farmer to get as good a rate of income from certain kinds of land for timber as from cultivating it in crops. While the use of timber as fuel has no particular interest for this Convention, the same general principle is true as regards fuel as is true of timber, and I am certain that any systematic effort to plant land with timber on mountain slopes would yield as large a return as planting it in crops in any part of the United States. It is true that to get the best kind of timber you have to wait a long time; but in planting a large area of ground, as the French and German Governments have been obliged to, the ground has yielded to the Government as good a return for the capital invested as any other. Their plan is to use it for timber, and the plan Mr. Collingwood suggested is the one they use; they plant a very large number of trees and then thin out. In the course of ten or fifteen years the ground begins to yield an income, and from that time yields an income every year, and as it is thinned out the timber gets more valuable. What is needed in this country is the passage of laws relating to trees. This subject was a matter of so great importance for the preservation of animals on the plains that it used to be my habit when I first went there to get the farmers together and talk to them about the cultivation of trees. I have known large forests of cottonwood to grow up within ten years so as to be large trees from fourteen to eighteen inches in diameter, but in those parts of the country it is only used as a protection against winds. The cottonwood is a great grower, and if anything can be done with it, it would be valuable on that account. But hard wood trees can be propagated as well as others, and what is wanted in this matter is not science but legislation.

A. M. WELLINGTON, M. Am. Soc. C. E.—It has occurred to me that,

while these efforts to preserve the timber supply are very commendable, yet from a certain point of view there is no danger whatever of our failing to have as much timber as it is for the public interest that we should use. The present use of timber in the United States is three or four times as great as in any other country for the same purposes, and five or six times as much as it is for the public interest that it should be. I question very much whether it is a public advantage to have timber over cheap. Even in our large cities the use of timber is much more general than in other parts of the world, and it can be shown by figures that the use of timber is actually costing the City of New York more for insurance and in the maintenance of the Fire Department, and in loss and injury to property, than it would cost to require all buildings to be made fireproof from the beginning. For railroad purposes also, for the platforms and buildings along the track, wood is entirely unsuitable. It is contrary to public interest that these should be built entirely of wood. It would cost very little more to erect brick or stone or concrete buildings or something of the kind, and in the end the public would be better served. I have been for some years in a country where wood is inconceivably scarce. It is found only in the furthermost recesses of the mountains, and when once cut it never grows again. Nothing in this country will compare with it. Nevertheless, the community get along very comfortably. Instead of building houses that will last only eight or ten years, or be burned down in six months, the buildings there will be as good one hundred years from now as they are to-day. To be sure, they require no fire for heating purposes. For cooking, they manage to dispense with wood to a very large extent. Sufficient wood is brought on the backs of men or donkeys from a distance of fifteen or twenty miles. In comparing that situation, which prevails in many parts of the world where civilization flourishes well, with the situation in this country, we find that we have an enormous area where timber will grow freely, and that our supply of timber is sufficient, with ordinary preservation and care, to answer all purposes, to give all the timber we really need. If timber gets high in price, people will use brick or stone and be more comfortable as well as more safe.

J. J. R. Croes, M. Am. Soc. C. E.—Will Mr. Wellington kindly name the country where he has been, so that it may go down as a matter of record?

Mr. A. M. Wellington.—I refer to Mexico. The civilization of

Mexico is higher than people imagine, although, of course, not as high as ours, and it is very interesting to see to what an extent it is possible to dispense with timber. For instance, such things as the piazzas about this building would be made, in Mexico, of light, graceful cut stone work, not much heavier than these piazzas are, and the effect is very beautiful. Here we build with wood, and they very largely with stone. We build in that way largely, I think, from habit. We build a handsome cut stone house and put a wooden piazza outside instead of building arches of stone; I think largely from the fact that they are so little used that it is not realized how little additional cost they involve.

Mr. EDWARD P. NORTH.—I am surprised to hear a Member of this Society expressing such sentiments. The inconvenience in Mexico from the lack of wood is something no man brought up in this country can understand. The impossibility of getting wood for structural purposes has been a continual drawback to the success of Mexico. They have made makeshifts at a great expense by which to build comfortable houses. The element of permanence which Mr. Wellington has spoken of I think is objectionable. As the country is now growing, with new wants and new appliances for satisfying those wants, any house built to-day will twenty years from to-day be inadequate. New appliances will be required which render it necessary that the house shall be taken down and a new one built in its place. In the City of New York there are not two per cent. of the houses, except in the poorest parts of the city, that are not altered in twenty or thirty years at a great expense, sometimes greater than if the houses were torn down and built from the foundation. The necessities of our country are growing so that permanence in a house either for residence or business purposes is not desirable.

Prof. T. EGLESTON.—I do not know about our houses not being permanent. I am the owner of a house built in 1783. It is a wooden house, and I had occasion to cut out some timber from it lately, mostly oak, and I think it is just as sound as when the house was built. That is pretty permanent I think.

Mr. A. M. WELLINGTON.—I do not think that any one can fairly draw the conclusion from what I said that the condition of things in Mexico in regard to the timber supply, or anything approaching to it, would be anything but a great public evil here. What I did say was that the

conditions in this country are such that, do what we will, there will always be an abundant supply for all legitimate necessities, and that a very large part of our use of timber is a public evil; not all by any means, and that the use of timber very often is not even an immediate economy. The most conspicuous example is in large cities, where wooden cornices, floors, walls, interior fittings, etc., create danger from fire, which costs a great deal more in the City of New York than it would cost to build in the first place of approximately more fire-proof material, so that fires would not be so ever present a danger as now.

Mr. F. COLLINGWOOD.—I think we may fairly quote in this connection such a country as Great Britain, which is drawing its supplies to-day from Canada, from this country, and from nearly all the world, and they find it necessary to do it. They can not get large timber except by doing so. I think, as engineers, we would find ourselves in great trouble sometimes if we could not get large timber. Some years ago I wanted to get some white oak piles for a bridge, and I had a good deal of trouble to find them. It is a question of economics. It is not that we cannot get the timber, that it is not in the United States, but the price of timber is rapidly increasing, and as the supply is exhausted which we are now drawing on, we shall have to go further for it, and it will cost us a great deal more. I would be very glad to take up the question of the effect of the destruction of our forests upon climate locally and upon the water supply. Every one who has lived upon a stream for 30 or 40 years knows what a change there has been as soon as trees have been cut off from its head waters. It is a necessity almost upon us to cultivate the growth of timber to help to conserve the water supply and make it more uniform.

CHAS. LATIMER, M. Am. Soc. C. E.—While I believe that it is a very good thing to preserve timber, and take care of the forests, I think with Mr. Wellington that we borrow a good deal of trouble. I remember, when I was in Buenos Ayres, I was very much shocked to find that all the wood that could be bought was peach trees, and I was very much astonished, when I was out there, at a very remarkable discovery—the discovery of oil in this country. Every one was expecting that the whales would give out and there would be no oil, and all of a sudden more oil was found than we could use. You remember Rankin wrote a paper: "What Shall We Do for Coal in England?" and now they have found that they have abundance of coal. In Wyoming Valley,

where they had a good deal of black coal, the question arose finally, "What are we going to do for cheap coal; it is giving out?" Well, in the Pittsburgh region they have opened up immense gas fields. The next question was, "What are we going to do for steel?" and we are making it now as cheaply as iron. And now the question arises, "What are we going to do for hoop-poles?" But iron is used for hoops almost universally. As to the question of building houses, Mr. Wellington spoke of everything but aluminum. We will have aluminum houses after awhile or some other metal, and not be bothered with wood. I think the trouble of cutting the forests is very much like killing the bears or killing the buffaloes. If you give up cutting timber for 50 years the whole country will be overrun with forests, and the question will be how to get rid of them. The question is not yet serious.

GUSTAV LINDENTHAL, M. Am. Soc. C. E.—There is an interesting point in the paper about the preservation of ties. I had occasion to talk with an official in Prague, Bohemia, on the question of renewing ties, and he said they found it a saving to use iron ties when oak ties reached the price of one florin. Iron is 25 per cent. cheaper there than it is here. In respect to the preservation of timber, I would like to state a fact. Preserved timber was used for a bridge floor in Pittsburgh, and to my disappointment and surprise I found it rotten in some places after one year, namely, the wooden blocks set on end between the tracks, where horses rarely step, or that portion of the bridge which is used the least. I am not quite satisfied as to the cause. I think that where the tracks are used the fiber is beaten down and compressed, in this manner excluding the water to a certain extent and preserving the wood. On the other hand, where the surface of the blocks is not compressed by travel the action of rain and sprinkling washes out the preservative and the loose grained and spongy wood rots faster than it would if not preserved. In London and other places, where wooden pavements are largely used, they wear off faster than they could rot. The question, where we shall get a supply of timber from in the future, is an important one. I think there is an invention for making artificial timber from straw. Should the price of timber get so high that we would be obliged to get a substitute for it somewhere, the inventors of this country may find a substance that can be manufactured cheaply. Where nature works slowly they may work fast.

O. CHANUTE, M. Am. Soc. C. E.—A number of questions have been asked which I should like to answer concerning the report of the Committee on the Preservation of Timber, but it is getting late, and there is other business before the Convention, and I suggest that other discussion be postponed until some future meeting, and that members be requested to present written discussions at that time.

J. N. TUBBS, M. Am. Soc. C. E.—It would be very interesting if the committee would extend their discussion, and make some practical suggestions as to the best methods of encouraging the preservation of our forests; whether it should be done under the control of the General Government or the State, or what should be done to encourage private enterprise in that direction.

Mr. O. CHANUTE.—I wish to state, in connection with the suggestion just made, that this committee has been at work for five years. It has made the report originally asked for, and it is hoped that the committee will be relieved from further duty, and that whatever action it may be desired that the Society shall take shall be introduced in the form of a new resolution.